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Mobile Laboratory Unit: a disruptor solution for hemostasis management during major surgery. Usage in the context of face transplantation

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Abstract

Background: The management of surgical bleeding during a face transplant in a patient diagnosed with bilateral neurofibromatosis is quite complex. With the actual methods and technology for hemostasis management, it may not always be possible to give the clinician the support needed to manage operative associated bleeding. Bedside hemostasis monitors are needed urgently to assist clinicians in making the correct diagnosis in a timely manner.
Methods: Our Mobile Laboratory Unit is a disruptive solution for hemostasis management during major surgery as it allows real-time monitoring, the predominant mechanism of bleeding and goal-direct coagulation therapy. The unit is an autonomous mobile platform that can be moved immediately to anywhere its service is needed and offers a complete flexible laboratory test which includes biochemistry, hematology and coagulation studies as standard equipment.
Results: In our case the test performed by the unit allowed us to identify the reason for our patient's bleeding at the bedside. Severely decreased clot firmness of the fibrin-based clot and a less impaired firmness of the whole blood clot, suggested an acceptable contribution of platelets to the clot quality, but decreased polymerization of fibrinogen into fibrin.
Conclusions: In our opinion new insights into the pathophysiology of coagulopathy, the availability of technology such as our Mobile Laboratory Unit, and awareness of side effects of intravenous fluids should encourage the idea that perhaps it is time to change hemostasis management in operation-related bleeding.

Keywords: bleeding surgery; face transplant; hemostasis management; Mobile Laboratory Unit; point-of-care testing.

Introduction

The causes of excessive blood loss during major surgery have been multi-factorial, and extensive research in this field over the last few years has significantly increased knowledge about the mechanisms. Hemostatic alterations during major surgery concern both pro- and anti-hemostatic pathways and this delicate balance may turn to either hypo-coagulation or hyper-coagulation. This complex hemostatic equilibrium can also be disturbed by hyperfibrinolysis, hypothermia, acidosis and anemia.

There is a marked institutional variability in methods and technology for hemostasis management during major surgery. In most centers, hemostasis is monitored with conventional coagulation tests performed at the hospital central laboratory. However, despite great improvements in graft preservation and surgical skills, hemostasis management during surgery is still a problem nowadays without having a satisfactory hemostasis solution. Complete bedside monitoring of hemostasis is urgently needed for the management of operative associated bleeding (1).

The concept of the Mobile Laboratory Unit, developed in our department, is a disruptor solution for complete hemostasis monitoring during major surgery (Figure 1). The unit is an autonomous mobile platform which is attended by laboratory professionals, can be moved immediately to whichever service needs it, and offers a complete flexible laboratory test, which includes biochemistry, hematology and coagulation studies, as standard equipment. Thanks to the collaboration of

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Figure 1 Mobile Laboratory Unit.

Roche Diagnosis Spain, this idea has resulted in a new development, the Mov1Lab®. This technology is presented for the first time with regard to its use in the management of surgical bleeding in the ninth face transplant performed in the world.

The Mobile Laboratory Unit is a new device capable of performing a broad menu of tests on a single portable platform, including routine biochemistry, hematology and coagulation tests. The mobile unit is a modular block 180 cm high×85 cm wide. The unit is fully flexible and can incorporate a variable number of analytical equipment. The unit we have formed for fast bedside hemostasis management includes: 1) Cobas b 221 (Roche Diagnostics, Mannheim, Germany) that allows the execution of the following parameters; sodium, potassium, chloride, ionized calcium, hemoglobin, urea, glucose, lactate, bilirubin, gas analysis in blood and CO-oximetry; 2) POCH-100i hematology counter (Sysmex, Mundelein, USA) for performing three population hemograms by flow cytometry; and 3) thromboelastometry (TEM) (Rotem Tem International GmbH, Munich, Germany) to measure the quality of whole blood clots. With the addition of other equipment, the unit can be expanded or modified to measure cardiac markers, HbA_{1c}, drug abuse, D-dimer, or even, more specialized biochemistry, infectious serology or molecular biology studies. All the incorporated equipments work with whole blood, the minimum amount required varies depending on the number of parameters, 650 µL are required for a complete analytical profile.

The unit is completed with software management that centralizes the control of analytical systems and permits the online connection of the unit. This software structure would allow us, under centralized control, to create working cells with multiple units with analytical profiles adapted to the different services or satellite laboratories.

Case report

A 36-year-old male with type 1 neurofibromatosis was admitted to our hospital for an elective intervention of partial face transplantation. His diagnoses included: plexiform neurofibroma of the lower two-thirds of the face, amaurosis of the right eye caused by glioma of the right optic nerve, ptosis of the lower lid of the left eye, and bilateral facial paresis. The patient had undergone 17 surgical interventions for the correction of facial neurofibromatosis, with repeated resection of hypertrophic tissues and corrective plastic surgery. The surgical procedure began with the ocular prosthetics for the right eye, followed by the facial graft procurement, extirpation of the facial plexiform neurofibroma, and, after 16 h of surgery, a stepwise anastomosis of the graft for the following 4 h.

Given the complexity and prolonged duration of the face transplantation, severe bleeding may occasionally occur. Type 1 neurofibromatosis is a congenital disorder which may affect any body tissue. Vascular anomalies include arterial stenosis, arteriovenous malformations and aneurysms. In patients with neurofibromatosis, bleeding events have been described relating to spontaneous rupture of major arteries (2), oozing during surgery, and even light trauma (due to fragility and hypervascularization of affected tissues) (3). Underlying clinical conditions play a major role; face transplantation has been performed in only one other patient with neurofibromatosis (4). Massive hemorrhage of subcutaneous tissues in patients with neurofibromatosis appears to be characterized by a fast onset and rapid progression to hemodynamic instability (5). For hemostasis monitoring the results obtained from a Blood-Gas-Analyzer placed inside the operating room and the results of the hematology and coagulation [activated partial thromboplastin time (aPTT), PT and fibrinogen) performed at the hospital central laboratory turnaround time 45 min (CI 95% 38–50)] were being used.

During extirpation of facial tissues affected by the tumor, the patient developed severe bleeding that required volume replacement therapy. At this moment, the test results showed a generalized alteration with severe prolongations of aPTT >400 s, and PT >320 s, low fibrinogen 0.49 g/L, severe low platelet count 48×10^9/L, hemoglobin 66 g/L, acidosis pH 7.25, and ionic calcium 0.93 mmol/L (Supplementary data, Table 1 which accompanies the article at http://www.degruyter.com/view/j/cclm.2012.50.issue-9/issue-files/cclm.2012.50.issue-9.xml). Over the following 4 h the patient

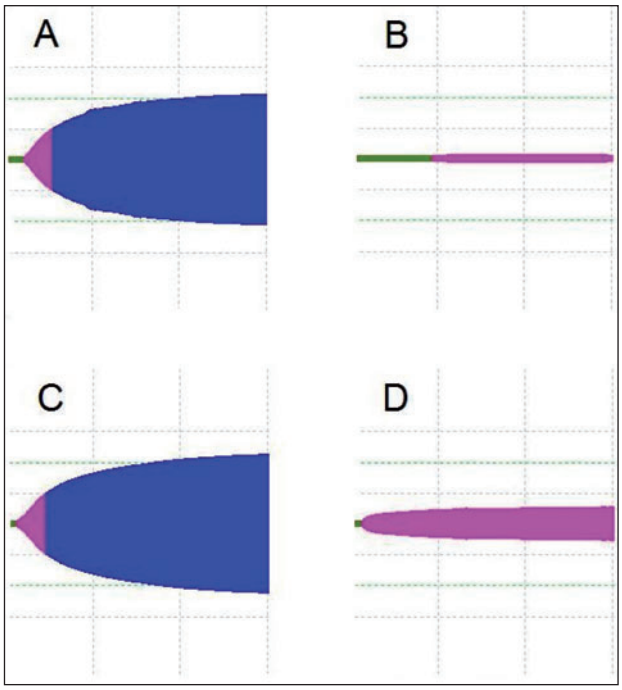

Figure 2 Thromboelastometry analyses.
Acceptable firmness of the whole blood clot (EXTEM test, A), with severely decreased firmness of the fibrin-based clot (FIBTEM test, B) before fibrinogen concentrate administration; improvement in clot firmness (EXTEM test, C and FIBTEM test, D) after fibrinogen concentrate.

needed massive transfusions of blood products [10 units of red blood cell concentrate (RBC), 4 units of freshly frozen plasma (FFP) and 2 units of platelet concentrate] due to a massive intra-operative blood loss and severe alteration of the coagulation tests. The predominant cause of bleeding in the complex scenario of tissues injury, ongoing blood loss, coagulation factor consumption and dilution through volume infusion could not be differentiated.

Due to ongoing diffuse bleeding, the Mobile Laboratory Unit was requested. This unit was moved to the operation room to allow immediate bedside analyses. The test performed by the unit allowed us to identify the cause of our patient's bleeding at the bedside; severely decreased clot firmness of the fibrin-based clot and a less impaired firmness of the whole blood clot, suggested an acceptable contribution of platelets to the clot quality, but decreased polymerization of fibrinogen into fibrin (Figure 2). The deficit was compensated by an initial dose of 4 g of fibrinogen and an additional dose of 3 g 30 min later, which markedly improved clot firmness and stopped the bleeding.

Conclusions

Recent reviews have concluded that, as in our case, with the actual methods and technology for hemostasis management it may not always be possible to give the clinician the support needed to manage operative associated bleeding, and bedside hemostasis monitors are urgently needed to assist clinicians in making the correct diagnosis in a timely manner (6). In our opinion, new insights into the pathophysiology of coagulopathy, the availability of technology such as our Mobile Laboratory Unit, and awareness of side effects of intravenous fluids should encourage the idea that, perhaps, it is time for changing hemostasis management in operation-related bleeding. In this way, our Mobile Laboratory Unit might be considered a disruptive solution for hemostasis management during major surgery as it permits real-time monitoring the predominant pathomechanism of bleeding and goal-direct coagulation therapy.

The use of thrombolastography, which was developed by Hartert in 1948 (7), has recently been included in the panel of laboratory monitoring for hemostasis by the American Society of Anesthesiologists (8). As opposed to routine coagulation testing in plasma, TEM can be performed at the bedside in whole blood, relevant information can be obtained within a few minutes and, therefore, goal-directed coagulation therapy can be rapidly initiated. The Mobile Laboratory Unit provided the information that the fibrin-based clot quality was severely decreased, while the patient had ongoing bleeding, insufficiently controlled by the standard therapy. Subsequent administration of fibrinogen concentrate improved the quality of both the fibrin-based clot and the whole blood clot. Besides facilitating fibrin-based clotting, it has been suggested that increased fibrinogen concentration may potentially compensate for decreased platelet contribution to clot firmness (9). In the present case, the clinical outcome of fibrinogen concentrate therapy was the cessation of severe bleeding. Similar effects of fibrinogen concentrate among patients with impaired fibrin-based clotting have been reported in settings such as trauma and major vascular surgery (10, 11). When major surgical blood loss is substituted with plasma-poor red cell concentrates, deficiency of fibrinogen develops earlier than that of other coagulation factors (12). Thus, fibrinogen concentrates may generally prove useful when extensive tissue laceration (e.g., excision of plexiform neurofibroma) causes severe diffuse bleeding. In such cases, rapid and efficacious hemostatic therapy is paramount (2).

The idea of a Mobile Laboratory Unit is a disruptor innovation and may revolutionize the services provided by clinical laboratories. The flexibility of this technology can provide in situ and in a short time fairly comprehensive laboratory services, in order to provide rapid diagnosis at the place of patient care, to any unit or clinical service that requires it. Although we are applying this technique systematically in the surgery area as an analytical support to high-risk surgery for bleeding such as cardiac surgery with out-of-body circulation or liver surgery (conventional and transplant surgery), as well as in other kinds of surgery such as in our case, further studies are required to definitively show the cost-effectiveness of the application of the idea in high-risk surgery. However, the ease of use of this technology and the possibility of being supported by laboratory professionals online, opens up the possibilities of its use beyond the hospital setting, such as providing some basic laboratory services to either primary care centers,

private medical practices, advanced life support ambulances, healthcare facilities in rural areas (13), medical units of the army, or in disaster and emergency situations (14).

Conflict of interest statement

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